# Lead

**Symbol:** Pb

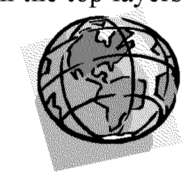
**Atomic Number:** 82
*(protons in nucleus)*

**Atomic Weight:** 207
*(naturally occurring)*

***What Is It?*** Lead is an element found naturally in rocks, soil, plants and animals. It typically occurs in combination with other elements as lead salts, some of which are soluble in water. The pure metallic form of lead is bluish-gray, but metallic lead rarely occurs naturally. Lead does not evaporate, but it can be present in air as particles. Because it is an element, lead does not degrade nor can it be destroyed. Several radioactive isotopes are naturally present in the environment, with lead-210 being the isotope of most concern. (Information on radioactive isotopes is presented in the companion fact sheets for radium, thorium, and natural decay series.)

***How Is It Used?*** Lead has been used for thousands of years for a variety of purposes. Today, its major use is in the production of certain types of batteries. Lead is also used to make ammunition, metal products (sheet metal, solder, and pipes), medical equipment (radiation shields and surgical equipment), paints, ceramic glazes, caulking, scientific equipment (circuit boards for computers), and high-precision glass for lasers and other optical equipment. In recent years, the amount used in products such as paints and ceramics has decreased significantly to help minimize exposures of people and animals. Tetraethyl and tetramethyl lead (volatile organic forms) were used for many years in gasoline to increase octane rating. In the United States, this use was phased out during the 1980s, and lead was banned from use in gasoline for transportation in 1996.

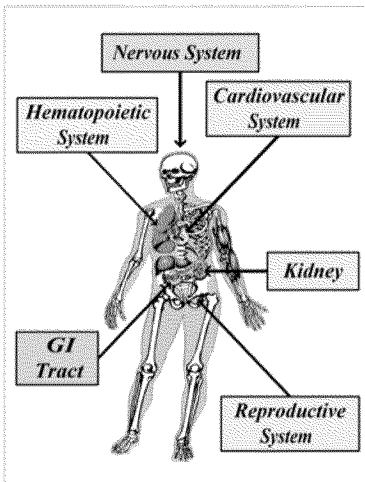
***What's in the Environment?*** Lead occurs everywhere in the environment. Concentrations in U.S. soil typically range from less than 10 to 30 milligrams of lead per kilogram of soil (mg/kg). However, amounts in the top layers vary widely and can be much higher due to human activities. For example, concentrations near roadways can be 30 to 2,000 mg/kg higher than natural levels due to past use of leaded gasoline. In air, concentrations typically range from 0.001 to 0.002 microgram per cubic meter ($\mu g/m^3$) in remote areas and from 0.2 to 0.4 $\mu g/m^3$ in urban areas. Levels in surface water and groundwater typically range from 5 to 30 µg/liter. Lead is relatively immobile in soil but can leach to groundwater over time. Concentrations in sandy soil particles are estimated to be 270 times higher than in the water in pore spaces between the soil particles; it binds even more tightly to clay and loam soils, with concentration ratios of about 500 to more than 16,000. Reported concentrations of lead in various foods range from 0.002 to 0.65 mg/kg, with higher levels generally found in vegetables. The typical ratio of the concentration of lead in plants to that in the soil on which they grow is estimated at roughly 0.04 (or 4%).



***What Happens to It in the Body?*** Lead can be taken in by eating food, drinking water, or breathing air. Children, and to a lesser extent, adults, can also be exposed by ingesting soil. Lead can also be absorbed through the skin, although this is usually a less important route of exposure. If air containing lead particles is inhaled, particles deposited in the lungs can lead to about 90% being absorbed. Particles deposited in the upper parts of the lung are usually coughed up and swallowed, while those deposited deep in the lungs can dissolve, allowing lead to enter the bloodstream. If lead is swallowed with food, the amount absorbed into the bloodstream is about 10 to 15% in a typical adult; however, about 60 to 80% is absorbed in adults who have not eaten for a day. In general, if adults and children ingest the same amount of lead, children will absorb a higher percentage (about 50%). After lead enters the bloodstream, it travels to three main compartments: blood, soft tissue, and bone. About 95% and 73% of lead in the body is stored in bones and teeth for adults and children, respectively. Lead has a half-life in blood of about 1 month, whereas lead in bone has a half-life of greater than 20 years. Inorganic lead is not metabolized in the body, but it can be conjugated with glutathione. About 75% of absorbed lead is excreted in urine and about 25% in feces; lead can also be excreted in breast milk.

***What Are the Primary Health Effects?*** Lead can affect almost every organ and system in the body, including the gastrointestinal tract, the hematopoietic system (blood-forming tissues), cardiovascular system, central and peripheral nervous systems, kidneys, immune system, and reproductive system. Young and unborn children are extremely sensitive. Exposure of pregnant women to high levels can result in premature births and smaller babies, followed by learning difficulties and reduced growth. The latter effects are also seen in young children exposed to lead after birth, as are effects on other organ systems. In adults, peripheral nerve damage has been observed at 40 to 60 micrograms of lead per deciliter of blood (µg/dL) anemia at 80 µg/dL, and encephalopathy at 100 µg/dL. Although studies indicate that lead acetate and lead phosphate cause cancer in laboratory animals, we do not know

if lead can cause cancer in humans after being ingested or inhaled. On the basis of the animal studies, the U.S. Environmental Protection Agency (EPA) has classified lead as a probable human carcinogen. The joint toxicity of lead with other chemicals, including essential nutrients, has been studied more extensively than for most chemicals. Depending on the endpoint and chemical, the joint toxicity can be additive, higher than additive, or less than additive. For example, higher toxicity to the nervous system is predicted in combination with arsenic, cadmium, or manganese. In contrast, kidney toxicity is predicted to be less than additive for these same metal pairs. Zinc can protect against lead toxicity by reversing its enzyme-inhibiting effects, whereas iron deficiency appears to increase the gastrointestinal absorption of lead leading to increased toxicity to the hematopoietic system as well as other effects. Additional information is provided in the companion fact sheet on chemical mixtures.




*Organs and systems affected when lead is taken in through food, water, or air.*

***What Is the Risk?*** Unlike most other chemicals, the potential for adverse health effects from inorganic lead is based on predicted or measured levels of lead in blood rather than on toxicity values. The EPA developed a mathematical model (the Integrated Exposure Uptake Biokinetic Model, IEUBK), to predict concentrations of lead in the blood of children resulting from exposure to lead in soil, air, drinking water, food, and other sources. Predicted blood-lead concentrations have often been compared to a concentration of 10 µg/dL to evaluate the health risk to children. Using the IEUBK Model, the EPA estimated the blood concentration of lead in children could exceed 10 µg/dL if the concentration of lead in soil at residences exceeds 400 mg of lead per kg of soil. Similarly, EPA used the Adult Lead Model to predict a soil concentration of 800 mg/kg that would be protective of the fetus of a female worker in an occupational setting and would also protect adult male or female workers. The EPA subsequently developed an All Ages Lead Model, and a draft integrated science assessment was released in May 2011 to support the national ambient air quality standard. Certain lead compounds have been shown to cause cancer in animals, and lead is considered "reasonably anticipated to be a human carcinogen." (For radioactive isotopes of lead, the cancer risks are included in the risks for radium and thorium as indicated in those fact sheets.) The EPA has not established a cancer toxicity value because of difficulties accounting for pre-existing body burdens and other influences (also note people are more sensitive to the noncancer effects). The organic compound tetraethyl lead is very toxic, and a standard EPA toxicity value is available to estimate the potential for noncancer effects from exposure to this form. The EPA value used to estimate the potential for noncancer effects following ingestion is the reference dose (RfD), which is an estimate of the dose that can be taken in every day over a lifetime without causing adverse health effects. The RfD for tetraethyl lead is 0.0000001 mg/kg-day; this was developed by studying test animals given relatively high doses and then adjusting and normalizing to a mg/kg-day basis for humans. A standard inhalation toxicity value for noncancer effects, the EPA reference concentration, has not been established for tetraethyl lead or other forms.

***What Are Current Limits for Environmental Releases and Human Exposures?*** To help track facility releases to the environment, the Superfund amendments addressing emergency planning and community right-to-know require releases of eleven lead compounds to air, water, or land be reported annually and entered into a nationwide Toxics Release Inventory. For lead arsenate, a release above 1 lb (0.454 kg) must be reported immediately, while for other lead compounds the amount is 10 lb (4.54 kg). The EPA requires that lead in air not exceed 0.15 µg/m$^3$ as a rolling three-month average. The drinking water action level for lead is 15 µg/L. The EPA defines hazardous concentrations of lead as: 40 µg per square foot (ft$^2$) in dust on floors and 250 µg/ft$^2$ for interior window sills of homes; 400 mg/kg in bare soil in children's play areas; and 1,200 mg/kg in bare soil in other parts of the yard. For the workplace, the Occupational Safety and Health Administration has established a permissible exposure limit (PEL) of 0.05 mg/m$^3$ for lead (metal) and inorganic compounds (as lead). Many other regulations and recommendations have been developed for lead to protect workers and public health.

***Where Can I Find More Information?*** More information can be found in the primary information source for this overview: the toxicological profile prepared by the Agency for Toxic Substances and Disease Registry (ATSDR) (via http://www.atsdr.cdc.gov/toxprofiles/index.asp). Other online sources include the ATSDR ToxFAQs (http://www.atsdr.cdc.gov/toxfaqs/index.asp), EPA's Integrated Risk Information System (http://www.epa.gov/iris), the National Library of Medicine Hazardous Substances Data Bank (http://www.toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB), and the draft EPA integrated science assessment (http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=226323).